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Splenectomy

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SPLENECTOMY

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INTRODUCTION

Because of the more or less mystery surrounding the physiology of the spleen, the subject of splenic removal has proven, to me at least, intriguing. Rather startling clinical results have been obtained by the expedient of removal of this organ in certain diseases, but the reason for this improvement is for the most part still unexplained. Accordingly, a study of the indications for the operation at once reveals several topics for speculation.

A fairly large number of disease conditions are included in the indications for splenectomy, consequently the literature touching on each of these conditions has of necessity been somewhat incompletely scanned. However, an attempt has been made to review as completely as possible the literature concerning the operation of splenectomy in each of these conditions.

It seems to me that an intelligent study of the operation of splenectomy should be based on a knowledge of the present conception of the physiology of the spleen, and it goes without saying that any discussion of removal of the spleen would be incomplete without a brief resume of its anatomy.

An attempt will be made in the following sections, therefore, to present not only a brief review of the literature concerning indications for splenectomy, but also the present thought concerning indications for the operation, and finally, a short review of the anatomy and physiology of the spleen.

HISTORY

The history of splenic removal extends far into the annals of medicine, as it was known to the ancients that the spleen is not essential to life. Aristotle wrote: "It is the position of the liver on the right side that is the main cause for formation of the spleen". Erasistratus maintained that the spleen was of no use in life, but Galen more conservatively spoke of it as an organ full of mystery, or "mysterii pleni organon". (Moynihan,63) The statement is frequently met with that the ancients practised removal of the spleen in the belief that it improved the wind of runners. The erroneous belief that the giraffe possessed no spleen is thought to have induced the removal of the spleen in these runners, since at that time the giraffe was believed to be the speediest animal. (Krumbhaar, 49) Griffin (39) states that the practice was also probably influenced by the prevalence of malarial splenomegaly at that time.

It is interesting to note that the first recorded splenectomy is supposed to have been performed on a human and thus preceded the removal of the spleen for experimental purposes from an animal. This is recorded as having occurred in the year 1549, and is doubly interesting because the physician in charge, one Fioravanti, called into consultation a barber surgeon by the name of A. Zaccarelli, to perform the operation. However, some doubt

has been cast on the veracity of this record, chiefly because the author described the spleen as of such great size "That you could not conceive it larger", yet stated it to weigh only a few ounces. (Moynihan, 63). In addition, Krumbhaar (49) states that the first positive statement as to the extirpation of the spleen is to be found in Pliny's "Natural History", where it is stated that: "This member (the spleen) hath a proprietie by itselfe sometimes, to hinder a man's running; whereupon professed runners in the race that bee troubled with the splene, have a devise to burne and waste it with a hot yron. And no marveile; for why? They say that the splene may be taken out of the body by way of incision, and yet the creature live never the lesse; but if it be man or woman that is thus cut for the splene, he or she looseth their laughter by the means. For sure it is that intemperate laughers have always great splenes". Paracelsus is also said to have advised physcians to excise the spleen wherever possible.

In the 17th century two doubtful cases of total removal of the spleen are recorded, both following prolapse of the organ from knife injuries. (Krumbhaar, 49).

The first experiments made upon the spleen were carried out by Malpighi in 1669, who ligated the splenic vein and artery of the dog without loss of its life. In 1676 Clarke performed the first experimental splenectomy

on a dog, with recovery of the animal following the operation. (Moynihan, 63).

In spite of several successful splenectomies in the 18th century; rest, diet, salves and blood letting were considered proper treatment for injuries of the human spleen (Krumbhaar, 49), and it was not until the 19th century, when Bardeleben in 1841 published the results of his classical experiments, that it became generally known that animals could thrive after removal of the spleen. (Moynihan, 63). Thus the way was paved for the question of the deliberate removal of the spleen in diseased conditions.

The first instance of such an operation is recorded by Quittenbaum in 1826 (the father of ovariotomy in Germany), who, after a series of experimental splenectomies, undertook the operation on a human being. The patient, suffering from ascites and cirrhosis of the liver (Banti's disease perhaps?), survived only 6 hours following the operation. (Moynihan, 63). The first case of extirpation of the spleen in America was performed by O'Brien in 1816 for prolapse of the organ following a knife wound, but it was not until 1855 that much thought was given to splenectomy for conditions other than accident or injury. (Krumbhaar, 49).

At about this time Küchler, a German surgeon, removed the spleen from a malarial patient who promptly died following the operation. This brought criticism from Simon,

an influential representative of the Surgical Association of Hesse, and in the word of Moynihan (63), "a long and bitter controversy resulted, Simon trying to discourage the operation and Küchler trying to justify it".

This temporary lapse in the surgery of the spleen was halted in 1888, when Sir Spencer Wells (95), an influential English surgeon, published the results of a series of three splenectomies. The esteemed position of Sir Spencer Wells in the surgical world was such that his authority gave absolute warrant for the performance of any abdominal operation, and thus it was not long before the removal of large spleens was being attempted. Interestingly enough, the successful case in Wells series was later found to be splenomegaly due to hemolytic jaundice. (Moynihan,63).

In 1882, Collier (19) reviewed the position of the operation of splenectomy and reviewed the 29 cases which had appeared in the literature up until that date.

From the year 1900, the popularity of the operation has increased rapidly, and in the last few years has been performed in many of the diseases associated with splenomegaly with gratifying results in many instances. The history of the operation in each of these diseases will be taken up under the separate headings.

ANATOMY

(a) Embryology

Although there is still a difference of opinion as to whether the spleen is derived wholly from the dorsal mesogastric mesenchyme or from the mesothelium as well, its anlage can be recognized in the human embryo of the fifth week as an elevation on the left dorsolateral portion of the mesogastrium. The mesenchymal tissue is later broken up by blood vessels and ingrowth of trabeculae from the capsule to form the reticular tissue and cells of the pulp cords. The Malpighian follicles are formed from the infiltration of lymphocytes into the adventitia of the arteries and the sinuses from dilated veins. (Krumbhaar, 50). According to Thiel and Downey (87), the earliest splenic vessels are branches of the mesenteric artery which continue to bifurcate and finally form a primitive capillary network that communicates with both arteries and veins. Finally there is a communication between the vascular capillary network and the primitive splenic sinuses, and the open circulation that is characteristic of the adult spleen is established. The pancreas and splenic vessels become retroperitoneal and the attachment of the spleen to the early mesogastrium is represented by its pedicle.

(b) Gross Anatomy

The spleen lies obliquely beneath the ninth, tenth, and eleventh ribs on the left side of the body, and may be marked out upon the surface of the body by drawing two horizontal lines from the spinous processes of the ninth dorsal and first lumbar vertebrae, these lines being joined by two vertical lines, one four centimeters to the left of the midline of the body and the other corresponding to the mid-axillary line. Within this space the spleen lies retroperitoneally, situated behind the fundus of the stomach, lying against the diaphragm, and covered by the lower ribs. Its three surfaces are the outer or phrenic surface, the gastric surface and the renal surface, which is applied to the upper and outer part of the anterior surface of the left kidney. Within the confines of the gastric surface lies the hilum for the entry and departure of the splenic vessels. (Moynihan, 63). The hilum lies directly in contact with or adjacent to the tail of the pancreas; through it courses the blood supply of the spleen proper. The splenic artery is a branch of the celiac axis of the aorta, and the splenic vein forms one of the roots of the portal vein, the other two being the superior and inferior mesenteric veins. Thus an important point arises in connection with the blood supply of the spleen, namely, that any stasis or obstruction in the portal system above the point of entrance of the splenic

vein may develop collateral circulation through the splenic vein. The pedicle, together with the splenic artery and vein, varies in its position. However, in about seventy five percent of the cases its course lies along the upper rim of the pancreas. Thus the approach and isolation of the splenic artery may be difficult because of its location behind the pancreatic ligament or because of a high fixation of the splenic flexure of the colon. From the hilum project the ligamentous structures which serve to hold the spleen in its normal location. These are the pancreatico-lienal, the gastro-lienal and the phrenico-renal-lienal ligaments. (Vincent and Hanrahan, 91).

In the adult the normal spleen may vary in length from ten to thirteen centimeters, in width from six to ten centimeters and in thickness from three to four centimeters. The average weight may be given as 225 grams, although spleens have been reported as normal when weighing 180 to 800 grams. The color is usually described as purplish-gray, and on cut section, the color is that of port wine. On the cut surface of the pulp may be seen tags of connective tissue framework, blood vessels and small round bodies which are lighter in color and measuring about one millimeter in diameter called the Malpighian corpuscles. (Vincent and Hanrahan, 91).

Microscopic Anatomy and Circulation of the Spleen

A somewhat detailed description of the histology and mode of circulation of the spleen is justified here, not only because it is important in the but little understood physiology of the spleen, but because of the interesting controversy as to the type of microscopic circulation within the splenic pulp.

The most striking feature of the splenic pulp is the Malpighian corpuscle, which reproduces very closely the germinal center of lymph glands. It is to Mall (56) that we are indebted for the conception of the spleen as a lobulated organ and for most of our knowledge of the circulation. He showed that the histological unit of the spleen is a small mass of splenic tissue surrounded by four to six trabeculae and into which the arteries and veins continue to subdivide until there is but a small mass of splenic pulp with a central arteriole and an encircling venule.

The framework of the pulp is composed of a very delicate reticulum which is filled with several different types of cells, among which are small mononuclear cells, large leukocytes--both granular and large mononuclear cells and large phagocytic cells with their extrusions plus many red blood corpuscles. Large giant cells and megakarocytes are occasionelly seen in the adult. (Vincent and Hanrahan, 91).

Aschoff (1924) has recently taken this frequent association of reticulum and fixed phagocytic cells, observed not only in the spleen but in other organs as well, as justification for considering the combination as a definite histological and functional entity which he calls the reticulo-endothelial system. (Tait and Cashin, 86).

The type of circulation between the above mentioned terminal artery and vein has been the subject of much discussion, but after forty years of controversy the question seemed to be finally settled by the conclusive experiments of Mall (57) in 1902, who demonstrated that the circulation of the red blood cells in the spleen is through the pulp spaces in passing from artery to vein.

PHYSIOLOGY

The search for a knowledge of the functions of the spleen forms one of the more interesting chapters in medical history. Nevertheless, there is still much to be known regarding this organ of which Galen spoke of as being full of mystery. It is not surprising that even toward the end of the last century DuBois-Reymond in his lectures on physiology summed up the situation by saying, "Now we come to the spleen. Of it we know nothing. So much for the spleen". (Beer, 6).

Inasmuch as it has long been known that the spleen is not necessary for life, most investigations have been based on the effect of splenectomy on the various processes of the body. But, as Krumbhaar (50) points out, removal of the spleen appears to be immediately and adequately compensated by other tissues of the body, and because of the variation in the ratio of the weight of the spleen and the body weight of the many species of laboratory animals, there has been considerable discrepancy in the recorded results of many such lines of investigation. Gross (41) also has shown that the volume of the spleen as a whole follows a definite curve in the life of the individual, and this may also have a bearing on the contradictory results which are frequently observed.

Notwithstanding, several definite functions can be

ascribed to the spleen today, one of these being its reservoir and contractility function. Roy (79) in 1881, described rhythmic contractions of the spleen which he thought to be independent of the systemic blood pressure. According to Krumbhaar (50), a plexus of non-medullated nerve fibers accompanies the splenic artery and is known to conduct regulatory impulses to the contractile smooth muscle fibers of the spleen. This power of contractility has been found to play an important part in the volume of the spleen. By means of ingenious X-ray photographs, Barcroft and his co-workers (4) have shown that change in volume of the spleen may expel about one third of the red blood corpuscles into the circulating blood stream. Thus the spleen may be a quick as well as potent source of hemoglobin when the demand arises. Recent studies would seem to attribute even more importance to the reservoir function of the spleen, for it has been found that removal of a large spleen is immediately followed by an elevation of blood pressure in much the same way as it is following the excision of a large peripheral arterio-venous fistula. (Holman, 46).

Another important function of the spleen seems to lie in its relation to blood formation. Information regarding this phase of splenic function has been derived mainly from microscopic examination of the spleen, from

comparative study of the blood in the splenic artery and vein, and from observations regarding the effect of splenectomy on the blood and the remaining portions of the haemato-poietic system. It is now known that in embryonic life the spleen plays an active part in blood formation. At about the time of birth, this function is for the most part transferred to the bone marrow, although white blood corpuscles continue to be produced. During infancy this is mainly lymphocytic but later the production of polymorphonuclear cells predominates. The spleen remains, however, a potential source of blood formation throughout life, and in severe anemias, hemolytic or hemorrhagic foci of erythro-poietic tissue may be found in the splenic pulp, sometimes to the extent that it produces the picture of myeloid metaplasia. It is thought that lymphocytes are normally produced by the Malpighian corpuscles, assisted to some extent by the splenic pulp. (Krumbhaar, 50).

Studies of the relative cell counts of the blood entering and leaving the spleen, according to Krumbhaar (50), have offered no evidence of the role of the spleen in blood formation.

Many investigations have been carried out regarding the effect of splenectomy on the normal organism. Earlier investigations (69) seemed to prove that a transitory anemia follows splenectomy in animals, but recent in-

vestigation (35) has shown that even simple abdominal incision will produce an anemia of the same severity as that occurring after splenectomy. However, the number and proportion of white blood corpuscles does seem to be altered by splenectomy. Immediately after operation, both clinically and experimentally, there is a great increase in the total number, sometimes as high as 30,000. This reaches a maximum during the first week and gradually returns to normal in about one month. The immediate increase seems to be primarily of the polymorphonuclear type of cells and is succeeded by an increase in the lymphocytes, so that at the time the total number of cells has returned to normal, there is a definite lymphocytosis. (Vincent and Hanrahan, 91).

The role of the spleen in blood destruction assumes significant importance in any consideration of the indications for splenectomy, especially when it may be seen that the various forms of anemia might easily be due to a perversion of the normal process of blood destruction. While the liver plays an important role normally in blood destruction and bile pigment formation, the spleen, on account of its size and close circulatory relation to the liver, is probably the most important of the extra-hepatic structures called into active play under pathological conditions. Experimental, clinical,

and chemical evidence seems to show erythrophagocytosis to be carried out exclusively by the phagocytic cells of the reticulo-endothelial system, (50), and Robinson (74) believes the phagocytic process to be an electro-physical phenomenon whereby foreign particles adhere to the splenic pulp cells.

In conjunction with the role of the spleen in blood destruction is its relationship to the fragility of the red blood corpuscles. This has been studied by means of effect of hypotonic salt solutions on the resistance of the red blood corpuscles to hemolysis. Following splenectomy this resistance is increased and it is probable that this is a factor in the lessened tendency to jaundice that follows the administration of hemolytic agents to splenectomized animals. (Krumbhaar, 50). Some authors (91) feel that the simplest explanation for the decreased tendency to jaundice is that the removal of an organ active in blood destruction causes less blood to be destroyed and therefore less bile pigment is formed.

The excellent results obtained by splenectomy in chronic thrombocytopenic purpura suggest an important relation between the spleen and the blood platelets. However, no satisfactory explanation has been advanced to explain this relationship. While the marked rise in

the platelet count, following splenectomy, suggests that platelet destruction is a normal function of the spleen, the comparative counts in the blood of the splenic artery and vein do not confirm it. (Holloway and Blackford, 45).

Several other functions of the spleen have been suggested, none of them, however, proven as yet. Many attempts have been made to associate the spleen with the metabolism of fats and iron, but according to Collier (20), this is still a much disputed question. Other functions attributed to the spleen include its relation to antigenic immunity, resistance to tumor formation, and nitrogen and carbohydrate metabolism. (Vincent and Hanrahan, 91).

In summary, then, much is left to be learned concerning the physiology of the spleen. Certain definite functions seem to have been proven, among them being the spleen's power of contractility and of acting as a reservoir. The spleen is closely associated with the functions of the entire reticulo-endothelial system, and during fetal life is an important organ of blood formation. During adult life the spleen continues to manufacture lymphocytes and large mononuclear cells, and should the necessity arise, may even undergo myeloid metaplasia. The spleen is an important organ in connection with red blood cell cestruction and bilirubin formation, and is

somehow connected with red blood cell fragility. Its relation to platelet formation and destruction is not understood, but that such a relationship exists is evidenced by the fact that splenectomy is of distinct benefit in thrombocytopenic purpura.

Indications for Splenectomy

Surgery of the spleen has been very appropriately (91) separated into two main divisions, a general and a special form. In general splenic surgery, which corresponds to the general surgery of any organ, operations are undertaken for lesions in the spleen that are essentially surgical in character, such as arise from trauma, displacement, infection and the formation of cysts and tumors. In the special form of splenic surgery, splenectomy is used as a curative or palliative measure in those diseases which are associated with splenomegaly or in those diseases in which the spleen is thought to be an etiological factor. Such diseases are to be found among the blood dyscrasias and in cirrhosis of the liver.

Because much is yet to be known of the etiology of many of these conditions, the reason for the improvement seen in cases subjected to splenectomy remains to be demonstrated, and hence this form of splenic surgery immediately becomes a highly interesting study.

General Indications for Splenectomy

(a) Trauma

Traumatic lesions of the spleen may be divided into subcutaneous injuries and open wounds. The subcutaneous injuries are usually the result of a blow received in the splenic region and include rupture and contusion of the spleen, while the open wounds are made by missiles and sharp instruments that penetrate the upper abdomen or thorax.

The subcutaneous injuries of the spleen are much more frequent than the open wounds except in time of war. (Vincent and Hanrahan, 91). In a series of 113 Johnston (48) found 96 ruptures and only 17 wounds. Contusions and ruptures of the spleen seem to occur most frequently in active males between the ages of 20 and 40 years, and as might be expected, a diseased spleen which is enlarged and has a tense, thin capsule, is more prone to rupture than a normal spleen. Hence rupture of the enlarged spleen of malaria has been frequently observed, and in a lesser number of cases of typhoid fever, tuberculosis, acute sepsis, splenic anemia and pregnancy. The rarity of rupture in the last mentioned condition, i.e., pregnancy, is stressed by Burnett and McMenemey (15). These men found only 14 reports of splenic rupture during pregnancy in the literature prior to 1930. Rupture of the normal spleen has also been reported, the first case in 1874.

Since then, 20 authenic cases and 7 questionable reports have appeared in the literature up until 1937. Zuckerman and Jacobi (100), who collected the above mentioned statistics on rupture of the normal spleen, feel that future cases should be carefully analyzed from the point of view of physiologic dynamics of the abdominal cavity and the anatomic relations of the splenic and pancreatic peritoneal reflections.

There is no absolute sign of subcutaneous injury to the spleen. The symptom complex is that of intra-abdominal trauma (91), and in the majority of cases presents the usual sequence of trauma, shock, and hemorrhage. Abdominal pain, general or localized in the left hypochondrium is a predominant feature, and at times the pain is referred to the left shoulder region. Ballance (3) stresses the importance of dullness on percussion in the left loin and splenic region, which he states is due to formation of blood clots in that region. Pool (72) emphasizes the rapid rise in leukocytes not accompanied by a relative fall in hemoglobin and red blood corpuscles (in any internal hemorrhage). Occasionally contusions and ruptures do not present instantaneous bleeding, but evidence themselves after a considerable interval by a sudden collapse that marks the onset of a severe and profuse hemorrhage. This is strikingly illustrated by the case of Lovatt-Wenger (55) in which the patient fell on her side and

7 days later suffered a sudden severe hemorrhage.

A variant from the usual history in a case of splenic rupture is to be found in spontaneous rupture of the organ without a definite history of trauma. These cases usually occur in the soft, overdistended spleen of acute fevers, as Malaria, typhoid fever, typhus fever, and acute septic splenitis. (Vincent and Hanrahan, 91). However, spontaneous ruptures are uncommon even in malaria. Noland and Watson (65) found only 3 cases among 30,000 patients admitted to the hospital in Colon during an eight year period. Leighton (54) reviewed 73 cases of spontaneous rupture of the malarial spleen that were reported between the years 1842 and 1921.

The treatment of subcutaneous injuries of the spleen is immediate operation. Ross (77) reported a mortality of 92.3% in unoperated ruptured spleens, and Beer (6) states that in traumatic rupture of the spleen the bleeding may be so profuse that immediate operation is demanded. Splenectomy is superior to suture or tamponade when laceration or maceration is extensive (25), or if the lesion involves the hilum of the spleen. Connors (21) favors immediate operation and mentions splenectomy as the operation of choice. Willis (97) collected 57 cases that were treated by splenectomy, reporting a mortality of 28.88%. Needless removal of the normal spleen, how-

ever, must be cautioned against (91), and easily accessible, superficial tears of the capsule may be treated by suture.

In civilian life, open wounds play a minor role in injuries of the spleen, and according to Vincent and Hanrahan (91), are complicated usually by injury to other structures within the abdomen or thorax. The treatment of these injuries is usually immediate operation, with splenectomy the operation of choice in dealing with the injured spleen. However, Dretzka (25) mentions that suture or tampon readily controls bleeding in the majority of stab or bullet wounds, and he stresses the importance of adequate pre-operative treatment of shock with blood transfusion. Wallace (92), in a series of gunshot injuries of the spleen collected during the World War, reported a mortality of 50% in uncomplicated cases and 63.6% in complicated cases.

(b) Displacements of the Spleen

Although the spleen is normally quite firmly fixed in its location in the left upper quadrant of the abdomen many cases of displaced or wandering spleen have been recorded. Spleens which have migrated in this way are known as prolapsed or ectopic spleens. In some cases the pedicle is greatly elongated and the spleen acquires a rather marked mobility within the abdominal cavity, extending in some instances, as far as the pelvic cavity. At any time in the course of its wanderings, the spleen is likely to become adherent to adjacent structures by adhesions, or torsion of the pedicle with circulatory embarrassment may occur. When the latter complication occurs, the resulting changes within the body of the spleen may vary from simple congestion to hemorrhage or gangrene. (Vincent and Hanrahan, 91)

Diagnosis of torsion of the pedicle of the spleen is often missed, the most common error being the diagnosis of an ovarian cyst with twisted pedicle. According to Lahey (51), in all cases of torsion there is great pain, temperature, high pulse, vomiting and shock, depending upon the degree of the torsion. In most cases where the diagnosis has been made, the splenic notches have been felt. The assurance that the kidneys are in their normal location is a great aid in the diagnosis.

The majority of displaced spleen that cause symptoms

should be treated surgically by carrying out one of two procedures, namely, splenectomy or splenopexy. However, splenectomy seems to be the better operation for splenic displacement (91), since it removes at once the cause of the trouble and prevents torsion which happens in about 20% of displaced spleens. The operative mortality was 7% in Johnston's series (48), and in his cases with torsion of the pedicle, the mortality was about 26%.

(c) Abscess of the Spleen

Contrary to the belief that one might assume, a review of the literature would seem to show that abscess of the spleen is not a very rare clinical entity. Splenectomy for splenic, perisplenic and parasplenic abscess was performed seven times prior to 1891 and according to Billings (9) Grand-Moursel collected 57 cases of splenic abscess in 1885 and Kuttner 116 cases in 1907.

Abscess of the spleen is almost always secondary to some infectious process and usually is metastatic in nature. The majority of reported cases have occurred following typhoid fever (31), but a fair number of cases have been reported in malaria (49), general infections and trauma (23). Splenic abscess was secondary to an operation for acute appendicitis in Fauntleroy's case (32) and secondary to influenza in Spear's case. (81).

The symptoms of abscess of the spleen are extremely variable and sometimes very indefinite. The principal symptoms are pain, splenomegaly, fever and emaciation. The localization of the pain in the splenic region and the occasional occurrence of left shoulder pain are the usual symptoms which call attention to the spleen as the seat of the disease process. (91).

The treatment of choice in abscess of the spleen is splenotomy and drainage (23), but since splenectomy has been performed in a few of these cases, the condition is

deserving of mention in a paper of this nature. Hagen, a German surgeon, is supposed to have performed splenectomy in nine cases of splenic abscess with but one death (23), and hence there must be cases where total removal of the spleen is to be considered. Billings (9) states that Finkelstein collected statistics for 11 splenectomies in splenic abscess with 8 recoveries and 3 deaths, a mortality of 27% as compared with a mortality of 21% in cases subjected to splenotomy. These figures would seem to indicate that splenectomy should be given further trial in the treatment of this condition.

(d) Infectious Splenomegaly

Under this heading is included the splenomegaly associated with certain of the chronic infectious diseases such as syphilis, tuberculosis, malaria, kala-azar, schistosomiasis and undulant fever. While splenectomy has been performed in most of these conditions, the rarity of such cases makes this division of the indications for splenectomy of interest only in passing.

Splenomegaly may be very common in congenital syphilis (5) and the chronic enlargement of the spleen may be due to gumma or to diffuse syphilitic splenitis. Eason (27) makes the comment that chronic syphilitic splenomegaly occurs also in the tertiary form of acquired syphilis and, interestingly enough, states that the sole clinical difference from Banti's disease may be the history or demonstration of syphilis plus abdominal pain and tenderness.

Splenic tuberculosis occurs in a primary and secondary form, the latter of which is not uncommon (98). It was found in 67% of the cases in children under 10 years of age and in 19% of the cases in adults between the ages of 15 and 90 (98).

Malarial splenomegaly, or "ague cake", may be a very troublesome feature of malaria. The splenic enlargement (which occurs in nearly every case of malaria) may be due to local irritation by the accumulation of malarial parasites in the spleen or it may be due to congestion caused

by distention of the blood sinuses with red blood corpuscles.

Surgical treatment of the above mentioned conditions, i.e., syphilitic, malarial, and tuberculous splenomegaly, may sometimes be advisable in order to remove a focus of infection. Before splenectomy is decided upon in cases in which an etiological factor may be correlated to syphilis, tuberculosis, or malaria, a thorough trial of general and specific measures should be made. (91).

Griffin (36), however, states that the results following splenectomy for marked splenomegaly associated with syphilis and anemia (after a thorough trial of anti-syphilitic therapy) seem to have justified the procedure. He reports prompt improvement in three cases treated in this manner. Biello (8) also recommends splenectomy in selected cases, stating that the patients respond much more satisfactorily following splenectomy. In tuberculous splenomegaly, however, he expresses doubt as to the efficacy of splenectomy, and mentions that beneficial results can only be obtained if it can be ascertained that the disease began in the spleen or is limited to the spleen.

In the tropical diseases accompanied by splenomegaly Kala-azar plays an important role. The disease, which is widely spread in Indo-China, Ceylon and Syria, occurs much less frequently in Central America. It is caused by

infection with the Leishmania organism, and usually the spleen is enlarged when the diagnosis is made, in many cases extending below the umbilicus. Later the liver is involved and the terminal stages are marked by emaciation and ascites. Splenectomy may offer some relief from the marked abdominal symptoms but very few cases have appeared in the literature. According to Osler (68) the mortality is over 80%, and because the infection is generalized, splenectomy does not therefore seem a very logical procedure.

Egyptian splenomegaly is a form of tropical splenomegaly caused by Schistosome infestation. The trematode does not usually invade the spleen and ova are rarely found except in the neighborhood of the large veins at the hilus. The splenic enlargement may progress to the terminal ascites which develops in many cases, but splenectomy is indicated particularly in the earlier stages. (Coleman and Bateman, 18).

Undulant fever, a specific fever caused by the Brucella melitensis organism, is accompanied by splenomegaly. Although the disease is not at all rare in this locality, splenectomy is rarely indicated in the chronic form and never in the acute form. If the splenomegaly persists after the septicemia abates and is accompanied by progressive anemia, splenectomy may be indicated. (Vincent and Hanrahan, 91).

(e) Cysts of the Spleen

Cystic disease of the spleen was first reported by Andral (1829) and is said to have been of the dermoid variety. (Novak, 66). Fowler suggested that cystic disease of the spleen may be the result of trauma, of peritoneal inclusions, of dilatation of the splenic sinuses, or from degeneration due to arterial insufficiency in infarcts and tumors. Novak (66), who divides cystic disease of the spleen into dermoid, parasitic, and non-parasitic cysts, states that the last mentioned group may be traumatic, inflammatory, degenerative, dilatation, or neoplastic in origin. Pool and Stillman (73) divide these cysts into three groups; the large hemorrhagic single cysts, the small multiple cysts and a rare group of polycystic degeneration. They state that the small multiple cysts do not demand surgical intervention but that the polycystic degeneration type indicates splenectomy. The large single cyst is the type usually encountered and splenectomy is not difficult in this variety. The parasitic cysts of the spleen are in most all of the cases due to the echinococcus parasite, and is rare as a cause of splenic disease. Cysts of the spleen are said to occur in about 2% of all echinococcus infestations and in a series in which the spleen was involved in 88 cases of echinococcus disease, the spleen was involved alone in about 45 of the cases. Splenectomy is the treatment of choice in these cases. (88).

(f) Neoplastic disease of the Spleen

Primary neoplasms of the spleen are rare, and even more rarely is the spleen the site of secondary metastasis. As might be expected, the diagnosis is rarely made until the efficiency of splenectomy as a therapeutic procedure is almost nil.

Because of its structure, the spleen may be the site of benign and malignant tumors arising from the connective tissue, lymphoid tissue and the endothelium. They include fibroma, lymphoma, spindle and round cell sarcoma, lymphosarcoma, angioma, endothelioma and reticulo-endothelial sarcoma. (Vincent and Hanrahan, 91).

According to Bush (16), there had been reported in the literature up to 1910, 24 undoubted cases of sarcoma of the spleen, and about 120 cases (52) have been reported up to 1935. Lymphosarcoma is probably the most usual type (52), although reticulo-endothelial sarcoma is not uncommon.

The condition is usually characterized by progressive increase in size of the spleen which is often painless or may give rise to symptoms associated with mechanical disturbances. The blood examination may be negative and symptoms usually only develop with the growth of metastasis, usually in the liver. (Vincent and Hanrahan, 91).

Early splenectomy offers the only therapeutic procedure with a reasonable chance of cure in malignant tumors

of the spleen. If there is any danger of disseminating the tumor cells by handling of tissues, the spleen offers ideal conditions, and usually, the prognosis is quite poor. However, temporary improvement has been noted following splenectomy. In Jepson and Albert's series of 32 cases, 11 splenectomies were performed with 3 operative deaths, 3 deaths of reoccurrence, 1 patient was lost from observation, and 4 patients were living at variable periods up to 7 years following the operation. Finkelstein (33) collected 33 cases of splenectomy in newgrowths of the spleen, with an operative mortality of 30%, and with 4 patients living long enough after the operation to warrant the possibility of a cure.

Other rare tumors of the spleen include angiomata and aneurism of the splenic artery. Angiomata are of interest because of the possibility of malignant transformation and hence the advisability of early splenectomy in suspected cases Aneurism of the splenic artery has been only occasionally mentioned in the literature (Pool and Stillman, 73), and splenectomy has been performed in only two of the reported cases, with success, however, in both instances.

Special Indications for Splenectomy

(a) Hemolytic Jaundice

This condition was probably first described in 1890 when Wilson reported cases of congenital jaundice associated with splenomegaly. Later this form of congenital icterus became associated with the names of Chauffard and Minkowski, and Hayem (1898) described similar cases that apparently were acquired. Chauffard is said to have first directed attention to the important fact that the resistance of the red blood corpuscles to hypotonic saline is decreased in this disease. (Pool and Stillman, 73)

The congenital form exhibits a striking quality, i.e., a definite tendency to appear in succeeding generations. It may appear in only one member of a family, but frequently, when such instances are investigated, decreased red blood corpuscle resistance without other symptoms may be found in other members. Other features of the disorder are jaundice, splenomegaly, and anemia. The anemia may be very moderate, the red cells numbering from three to four million. Reticulated red cells appear in large numbers, sometimes as high as 20%. (91). Recently, Thompson (89) has described an important diagnostic blood finding in cases of congenital hemolytic jaundice. This consists of the finding of red blood corpuscles whose diameter is smaller than normal, but which exhibit no central pallor. While the proportion of these cells is small, and hence difficult of demonstration except by accurate micro-

manipulator measurements, Thompson feels that the atypical forms of hemolytic jaundice can be differentiated from the true congenital and acquired forms of hemolytic jaundice on this finding alone.

The acquired form of hemolytic jaundice has been classified by Vincent and Hanrahan (91) into two types, an idiopathic and a secondary variety. The secondary form has been found to accompany a variety of conditions including malaria, tuberculosis, syphilis, liver cirrhosis, carcinoma and miscellaneous bacterial infections. This variety corresponds to the so-called atypical form of hemolytic anemias described by Thompson (89). He reported 15 of these cases in which he was unable to demonstrate the spherical microcytes of the congenital variety, and states that of these 15 cases, 3 died of reticulum cell sarcomas of the spleen, 2 presented positive luetic serology, and 1 had caseating tuberculosis of the spleen and lymph nodes.

While the etiology of this condition is as yet unknown, most investigators have attempted to demonstrate a causal relationship between the decreased resistance of the red blood corpuscles and the increased size of the spleen. (Moynihan, 63).

While patients with hemolytic jaundice are not usually troubled by its symptoms, splenectomy has proven to bring

about startling improvement. According to Moynihan (63) no operation in surgery gives such dramatic results. It is interesting to note that the first splenectomy in this disease was performed without knowledge of the correct nature of the patient's condition. This was performed in 1887 by Sir Spencer Wells of England (95), at least 13 yars before the disease was definitely recognized as a clinical entity. The patient was found well in 1914 (63) with the exception that her red blood corpuscles still exhibited increased fragility. Other instances where splenectomy was performed in this disease before its recognition as a clinical entity were the operations of Bland-Sutton in 1895 and Vaquez in 1907, but Micheli, in 1911 first performed the operation in a recognized case of hemolytic jaundice. (Miller, 62). In 1915 Elliott and Kanavel (30) collected 48 cases of splenectomy in hemolytic jaundice from the literature and commented upon a now recognized complication of hemolytic jaundice, the presence of accompanying cholelithiasis. Elliot (29) reported 17 additional cases in 1917, and stated at this time that splenectomy, which seemed a cure for the disease, presented an operative mortality of 16%. He suggested that gallstones should be dealt with at subsequent operation and not at the time of splenectomy. Griffin (37) supports this view, stating that the removal of gall stones from hemolytic jaundice patients at the Mayo Clinic failed to

cure the disease, but that splenectomy without removal of the gall stones seemed to relieve the patients of their anemia and jaundice. He reported gall stones in 58% of their patients with this disease, and Mayo (60) reported them in 68% of the patients seen up to 1926. Dawson (24) favors removal of the gall bladder and spleen at the same operation.

While patients with congenital hemolytic jaundice are not usually troubled by its symptoms, the acquired variety is usually more severe, often being acute and rapidly progressive. In the typical form of the disease splenectomy is usually quite as effective as in the congenital variety (91), and Thompson (89) fairly well sums up the present opinion as to the value of splenectomy in hemolytic jaundice when he states that the symptoms of typical hemolytic jaundice are promptly, completely and permanently relieved by splenectomy. He stresses the advisability of correct diagnosis, however, since the atypical forms of the disease have not shown the remarkable therapeutic results from splenectomy as the congenital form. It has been said that congenital hemolytic jaundice is the one medical condition in which splenectomy is universally accepted as being indicated (53).

In summary, then, hemolytic jaundice seems to be at least one condition in which splenectomy is of startling

therapeutic value. Although the reason for the improvement seen in these patients following operation is not known, most investigators seem to agree that there is no improvement in the resistance of the red blood corpuscles to hypotonic saline. The operative mortality was about 16% in cases subjected to operation before 1917 (29), but the mortality in 88 operated cases reported by Mayo (61) in 1928 was only 4.5%, and hence the risk of the procedure seems to be more than compensated by the marked improvement seen in operated cases.

(b) Thrombocytopenic Purpura

Two centuries have elapsed since Werlhof (1735) originally described a case of essential thrombocytopenic purpura, but most of the advances in our knowledge of the disease have been made in the past 50 years. It was not until 1887 that the next significant advance in the recognition of the disease was made. In that year Denys pointed out the diminution in blood platelets so characteristic of the disease and Hayem in 1895 called attention to the non-contractility of the blood clot. (Eliason and Ferguson, 28).

Essential or primary thrombocytopenic purpura occurs in an acute and a chronic form, the latter of which is by far the most common. The disease is characterized by the either continuous or intermittent spontaneous extravasation of blood into or under the skin and mucous membranes. Other signs of the disease are a diminished platelet count, a prolonged bleeding time, a normal coagulation time and absence of clot retraction. The appearance of petechiae in the skin distal to a tourniquet blocking venous but not arterial flow is said to be a constant finding, and the presence of a secondary anemia without constant changes in the red blood corpuscles plus a usual slight increase in the white blood corpuscles may be found. The conditions which must be carefully differentiated from thrombocytopenic purpura are acute aplastic anemia, mild hemophilia, acute

leukemia and the rare splenomegaly of indeterminate type (Griffin, 39). However, if the above symptoms and signs are carefully recorded in every case of purpuric bleeding, little difficulty in the diagnosis will be encountered. (Eliason and Ferguson, 28).

The basic cause of the affection is unknown but certain facts about the pathogenesis of the condition are known. Rosenthal (76) states that the hemorrhagic manifestations of the disease are the result of not only the marked diminution of the blood platelets but also the result of changes in the endothelium of the capillaries. Frank is said to have stated that there is a lack of normal platelet production from the megakarocytes of the bone marrow because of a toxin elaborated by the spleen. Kaznelson, on the other hand, held the opposite view, i.e., that the disease is due to increased platelet destruction which results from excessive thrombolytic activity of the spleen and probably other part of the reticulo-endothelial system. (Vincent and Hanrahan, 91). Recently (1938) it has been found that the spleens from splenectomized thrombocytopenic purpura patients contain a substance which has the property of reducing the platelet count in the circulating blood of normal rabbits as much as 90% (90). This therefore appears to be additional evidence that the spleen plays a prominent part in the etiology of this condition

and would seemingly substantiate the theory that the spleen exerts a marked influence on platelet destruction.

Although the cause of this condition remains obscure, the treatment is much more effective than in other forms of purpura. In 1917, at Kaznelson's suggestion, Schloffer of Prague performed the first splenectomy in a case of thrombocytopenic purpura. The dramatic results of the operation, though still resting on an empirical basis, soon became entrenched as the most effective form of therapy in the chronic form of the disease. (Brown and Elliott, 12). In 1926 Whipple (96) reviewed 81 cases in which splenectomy had been performed with an operative mortality of 15%. At this time he stated that splenectomy had contributed the greatest advance in the therapy of the purpuras, but cautioned that the results were mainly those of the chronic variety of the disease. In 1928 Spence (82) added 23 more cases bringing the number of cases which had been splenectomized up to 104. In 1932 the total number of cases that had been splenectomized was 213, with an operative mortality of 13% for the total series, but with a mortality of only 7.08% in the 113 cases reported since 1928 (28). Cures were reported in 73% of the cases in this series, with only 2.8% remaining unimproved. In 1934 Pemberton (71) reported the result of 57 cases operated at the Mayo Clinic bringing their total

mortality to 7%, with complete remission observed in 73% of the patients.

The immediate effect of the operation in this disease is quite startling--the bleeding and the tendency to bleed being promptly checked. The platelet count rapidly increases following the operation, reaching a normal value in about 1 week. After this, however, the platelet count tends to fluctuate, seldom sinking to the low point which marked the onset of abnormal bleeding before splenectomy. (Vincent and Hanrahan, 91).

Until comparatively recently most surgeons thought splenectomy definitely contraindicated in the acute form of the disease. In Whipple's (96) series (1926) there were 7 deaths in 8 cases of acute purpura that were subjected to splenectomy, and Spence (82) in 1928 reported 10 deaths in 12 cases operated. Eliason and Ferguson (28) reported an operative mortality of 34% for the 35 acute cases in their series, but called attention to a drop in mortality to 13.6% between the years 1928 and 1932. In 1936 the available statistics (12) would seem to indicate an operative mortality of about 7% for all cases of thrombocytopenic purpura, with acute cases at about 14% and chronic cases 5 to 6%. Factors responsible for this decline in operative mortality may be the occurrence of more accurate diagnosis, better preoperative preparation,

and advance in surgical technique (12). Marsh (58) states that splenectomy may be seriously considered when transfusion fails to cause cessation of bleeding in a patient with acute thrombocytopenic purpura who is afebrile and whose blood count and general condition with the aid of transfusion insure a fair surgical risk. Smith (80) mentions that delay in operating these cases merely adds to the risk.

In summary it may be stated without fear of contradiction that splenectomy is generally recognized as the treatment of choice in chronic idiopathic thrombocytopenic purpura. More and more authors are swinging to the rationale of early operation in the acute form of the disease, most of them however, stressing the importance of accurate diagnosis as well as adequate preoperative preparation. The mortality is no longer so high that it can be considered a contraindication to a measure which, when performed under carefully controlled conditions may be the means for saving life, and the subsequent course of operated cases justifies the risk inherent in a major operative procedure.

(c) Splenic Anemia

This disease, the later manifestations of which form a syndrome known as Banti's disease, has proven to be one of the most baffling of the various blood dyscrasias. Banti, in 1894 clearly described the pathologic lesions of the enlarged spleen of this disease, and again in 1910, its symptoms and course. (Rosenthal, 75). Since the disease is always accompanied by an anemia of varying severity, Osler (67) advocated that the term splenic anemia be used. He described the disease as a chronic affection, probably an intoxication of unknown origin, characterized by a progressive enlargement of the spleen which cannot be correlated to any known cause such as malaria, leukemia, cirrhosis of the liver, etc.; anemia of the chlorotic type; a marked tendency to hemorrhage, particularly from the stomach; and in many cases having a terminal stage with cirrhosis of the liver, jaundice and ascites (Banti's disease). The terms splenic anemia and Banti's disease should not be used interchangeably (91), but should be so separated that the designation of Banti's disease is limited to those cases of splenic anemia which in the later stages have developed hepatic cirrhosis.

There have been many arguments that the syndrome originally described by Banti never occurs. Chaney (17) believes that the spleen plays the same role in all splenomegalic anemias, and he states that the microscopic appearance is

not characteristic in any of these conditions, rather being, probably, the result of fibrosis in the presence of secondary splenic enlargement. Some men believe that the existence or non-existence of Banti's disease per se depends very likely on the question whether or not there is sufficient reason to differentiate the disease from primary cirrhosis of the liver (91), and believe that there may be some ground for the belief that the syndrome probably represents three different conditions, namely, splenomegaly with secondary anemia, splenomegalic liver cirrhosis, or thrombophlebitic enlargement of the spleen.

It may be seen from the above statements that the pathogenesis and etiology of splenic anemia re far from being understood at the present time. Banti believed the disease to originate primarily in the spleen, with toxins acting directly on this organ. As a result, he said, splenomegaly developed, and following this the disease passes through a transitional stage, ending with cirrhosis of the liver. (Rousselot, 78). Although many arguments have been advanced to dispute this theory of the course of events in this disease, few actual facts have been brought forth either pro or con. Warthin (93) emphasized the clinical similarity between Banti's disease and the splenomegaly that develops secondary to chronic splenic vein thrombosis, and McNee (64) believed that portal

stasis plays an important part in Banti's disease; neither of these men, however, offering convincing proof of the correctness of these assumptions. An excellent resumé of the present thought concerning the course of events in this disease is to be found in the recent report of Rousselot (78). In an exhaustive study of 31 cases of splenic anemia, this author points out several heretofore unemphasized aspects of the etiology of this condition. In his series, the most common symptoms of the onset of the disease were a gradually developing weakness, gradual enlargement of the abdomen, hematemesis, pain in the abdomen, epistaxis, and various digestive disturbances such as anorexia, weight loss, nausea and vomiting, belching and diarrhea. The best laboratory aid to diagnosis was the routine blood count; the fragility of the red cell, bleeding time and clotting phenomena all being within normal limits.

Special emphasis was placed upon the finding of a tense, dilated portal and splenic venous bed. Rousselot (78) stated that this finding was invariable in those cases subjected to operation or post mortem examination, regardless of whether the case fell into the splenic thrombosis, Laennec cirrhosis, Schistomiasis, etc., forms of splenomegalic anemia, or into the larger group of cases where no obstructive factor could be demonstrated. Because of this

apparently constant pathological finding, pressure readings in the splenic vein were taken in cases subjected to operation. The results showed a definite rise in the splenic venous pressure in certain cases of hepato-splenomegaly as contrasted with normal readings in cases of hemolytic jaundice. Hence Rousselot believes that the factors of increased portal pressure and the entry of toxic substances in the portal circulation offer the best possible explanation of the etiology of the disease. The above somewhat lengthy discussion as to the etiology of splenic anemia is, I believe, justified here because of the almost total lack of understanding of the disease and hence the total lack of rhyme or reason for the operation of splenectomy here.

As is true of many of the conditions alleviated by splenectomy, the reason for the improvement seen in splenic anemia patients subjected to the operation is unknown, but certain it is that many patients are helped by the procedure. Rosenthal (75), in reporting 16 cases of splenic anemia that were operated, stated that 3 patients died within one year, 10 remained well from periods of 4 months to 10 years, and 3 were unimproved, having hematemesis one to two years following the operation. Mayo (61) reported 15 hospital deaths in 140 cases operated at the Mayo Clinic, but stresses the fact that this rather high

operative mortality was partially due to the reason that a goodly number of the patients were in the terminal stages of the disease, i.e., with advanced liver cirrhosis. Because many of the patients remained well for several years, he regarded the results as satisfactory. Dawson (24) on the other hand, points out that splenectomy in this disease presents no such good results as are obtained in hemolytic jaundice and thrombocytopenic purpura. He emphasizes that although operation benefits the anemia, it does not cure the already existing cirrhosis of the liver, and further illustrates his point by stating that in over 50% of the cases proven at post mortem to be nodular fibrosis of the liver, splenomegaly has been the earliest sign to appear in life. He quotes figures from the Mayo Clinic up to the year 1932 in which only 80 of splenectomized cases are reported alive.

Splenectomy is of considerable value in the more chronic varieties of the disease (91), but it is in this form of the condition that the technical difficulties of the operation are at a maximum, due to the large number of extremely vascular adhesions surrounding the enlarged spleen. The operative mortality has been reported to be from 10 to 25% (91) in the various clinics. Moynihan (63) points out that the only treatment that has proven of any value whatsoever in splenic anemia is splenectomy, but that the diffi-

culties of the operation are greater than in other diseases in which splenomegaly occurs. Biello (8) urges early operation in splenic anemia, stating that prior to involvement of the liver and occurrence of gastric hemorrhages, the chances of the patient to be benefited are high. He emphasizes that even in the terminal stages laparotomy should be performed with the view of splenic removal if possible, since the mortality in unoperated cases is invariably 100%. Rousselot (78) reports the poorest results from splenectomy in cases of Laennec's cirrhosis, but states that 66% of his patients who were subjected to splenectomy are alive from 2 to 13 years following the operation. He believes that splenectomy releases the inhibitory effect of the spleen on blood formation, permitting a gradual return of blood values to normal. Rosenthal (75), who believes that the blood platelet level in splenic anemia has not received the attention that it deserves, divides the disease into 2 main groups on the basis of the number of blood platelets in the circulating blood, i.e., a thrombocytopenic and a thrombocythemic group, and he reports excellent results following splenectomy in the first mentioned group. In the thrombocythemic group he reports a rapid increase of the platelets to enormous numbers following splenectomy, and states that this is associated with repeated thromboses and consequent postoperative hemorrhages.

One author offers the suggestion (14) that the likelihood of postoperative splenic vein thrombosis may be reduced by limiting operative interference to ligation of the splenic artery, but too few reports on the efficacy of this procedure are found in the literature in order to draw any conclusions as to its value.

Hence it may be seen that splenectomy in splenic anemia does not enjoy the prestige that it does in thrombocytopenic purpura and hemolytic jaundice. Nevertheless it may be said that the operation is the treatment of choice in this condition, not only because the disease in most instances runs a fatal course without operation, but because no other form of therapy has yet been advanced to replace splenectomy. In the last analysis, then, splenectomy is a justifiable procedure in this condition except possibly in those cases in which a terminal stage of the Banti syndrome has developed.

(d) Sickle Cell Anemia

Since Herrick originally described in 1910 the disease which he called sickle cell anemia, there have been numerous articles in the literature concerning cases of this disease. (Hahn, 43). The anemia, whose essential feature if the occurrence of crescentic red blood cells in the blood stream, until recently was believed to occur only in the negro race. According to Haden and Evans (42), there have been reported in the literature up to 1937, six cases of the disease in the white race. The clinical features closely resemble those of hemolytic jaundice, but in sickle cell anemia, the red blood cell resistance to hypotonic saline solution is increased or normal; the spleen is only occasionally enlarged; and there are usually certain features that are not present in hemolytic jaundice, such as leg ulcers, joint pains, and crises of abdominal pain. A latent sickle cell trait may be found in most of the relatives of a sickle cell anemia patient, but this is not incompatible with perfect health and long life. It is believed to be a hereditary characteristic, behaving as a dominant according to the Mendelian law of heredity. There is no proportionality between the degree of anemia and the ability of the red blood cells to form sickle cells in vitro. (Hahn, 43).

Splenectomy in sickle cell anemia was apparently first suggested by Sydenstricker and Huck (84) in 1924, and Sydenstricker later (85) reported a case where splenectomy

was attempted but the operation not completed. In reporting a case in a 3½ year old boy, Dreyfoos (26) stated that he advised splenectomy but that it was not done.

The first case of sickle cell anemia actually treated by splenectomy was reported by Hahn and Gillespie (44) in 1927, the results of the operation being quite satisfying. Their patient became symtomatically well in a short time and remained so for at least one year, with an immediate decrease in the excretion of urobilin. Hahn (43) also reported a second case subjected to splenectomy in 1928. The results in this case also were very encouraging, the patient being transformed from a cachectic infant to a normal healthy appearing subject in 8 weeks time. The sickle cell trait, however, persisted. Stewart (83) reported a case subjected to splenectomy in 1927, but submitted no follow-up report as to the course following operation. Up to the year 1937, only 10 cases of splenectomy in sickle cell anemia have appeared in the literature (42), all of these being performed on young children, and, according to these authors, in most instances without an excessively large spleen. The greatest improvement has followed the removal of the larger spleens, but in none of the cases has a sufficiently long follow-up been made in order to determine the value of the operation. (42).

Thus it may be seen that the procedure of splenectomy as a therapeutic weapon in sickle cell anemia is still well within the experimental stage. Early reports seem to favor the application of the operation to this disease, and as Hahn (43) points out, most of the indications for splenectomy seem to be present, namely, excessive hemolysis, compensatory activity of the hemopoietic tissue which is evidenced by the excessive output of nucleated and reticulated red blood cells, and finally, high leukocyte count plus abdominal pain and splenomegaly. The operation is not a curative measure (42), but is an aid in the treatment of the disease. Further study is necessary before conclusions of any value may be drawn.

(e) Familial Gravis Neonatorum (Erythroblastosis Fetalis)

This condition is a macrocytic hemolytic anemia attended by intense bilirubinemia and jaundice, developing either before or just after birth. The blood picture is characterized, in addition to a bilirubinemia, chiefly by a high percentage of nucleated erythrocytes, most of which are normoblasts. The liver and spleen are enlarged. (Penberthy and Cooley, 70).

Because the disease has been treated by splenectomy in three instances, all of recent date, it is of interest here. Penberthy and Cooley (70) reported the first two cases which were subjected to splenectomy in 1935, and Lawerence (53) reported a third case in 1937. Prior to 1935 the only treatment in this disease had been mainly symptomatic, although blood transfusions in repeated numbers had reportedly saved some cases. The results in the two cases of Penberthy and Cooley would seem to show that the disease is benefited by the operation, and Lawerence reported that his case, operated at 7 days age, was apparently normal at 15 months age.

Therefore the operation should probably be given further trial in this condition, but no accurate statement as to its value can be given at the present time.

(f) Gaucher's Disease

This relatively rare condition is a congenital, non-hereditary familial disease which was first described by Gaucher in 1882. It usually manifests itself in infancy or childhood and usually runs a slowly progressive course of years duration unless a fatal termination results from accident, operation or some intercurrent infection. The principal clinical and pathological features of the disease are enlargement of the spleen and liver, accompanied by an extensive infiltration of the liver, spleen, lymph nodes and bone marrow with large clear cells called Gaucher cells, which contain a substance called Gaucher substance. (Vincent and Hanrahan, 91).

Gaucher believed the condition to be neoplastic in character, (91), but the conception of Gaucher's disease as an epithelioma or a primary hyperplasia of the spleen has been replaced by the generally accepted belief that the affection should be classified among the systemic diseases. Waugh and McIntosh (94) believe the disease to be a primary systemic disorder of the hematopoietic tissues characterized by an irregular perverse myeloid metaplasia.

Although no method of treatment has been found that will cure Gaucher's disease, splenectomy is the only form which has found favor. According to Cushing and Stout (22) splenectomy was performed in 29 of the 49 cases of Gaucher

splenomegaly reported up to 1926, with an operative mortality of 20%. Apparently the operation was performed because the spleen was the chief organ affected by the disease, and although the disease was known to be a generalized affection, in the majority of cases the operation was followed by symptomatic improvement. However, there exists but very little data as to late results of splenectomy in the disease (22), and in 1926, only 5 cases had been followed for 5 and 10 year periods. Although the follow-up results in this meagre series were encouraging, (with only two cases not altogether well), it must be remembered that it is not uncommon for these patients to maintain fair health for long periods of time. At the Mayo Clinic, where the rarity of Gaucher's disease was well shown by a series of 4 cases among 530 splenectomies, the conclusion was drawn that splenectomy, although not to be regarded as a curative measure, should be looked upon as a means of affording great relief to the patient and possibly of arresting indefinitely the course of the disease. (Bonta, 11). Although Beer (6) feels that splenectomy should not be performed in this condition, Biello (8) favors the operation as the one method which has shown any promise whatsoever.

Thus it may be seen that in Gaucher's disease we have another of the obscure splenomegalies where the indications for splenectomy are still to be questioned. Since the

disease is apparently a generalized systemic involvement, it is to be seriously questioned whether or not removal of one focus of the disease (in the spleen) is of curative value. Here again it may be concluded that it is yet too early to judge the value of the operation, but it would seem that a too hopeful attitude is not to be assumed.

(g) Hodgkin's Disease, Leukemia, Pernicious Anemia and Polycythemia Vera.

The conditions known as Hodgkin's disease of the spleen, leukemia, pernicious anemia, and polycythemia vera are chiefly of value from a historical point of view. Splenectomy has been performed at one time or another in the history of each of these conditions, but at the present time the operation seems for the most part to have fallen into disrepute in all of the above diseases.

The spleen is involved in from 60 to 70% of the cases of generalized Hodgkin's disease, and such additional features as general lymph gland involvement, fever, and eczematoid dermatitis usually overshadow the abdominal picture. Since the disease seems to be a generalized involvement of the lymphatic system, the operation of splenectomy would seem futile (91), and it is only rarely that an operation such as this has been performed. Moynihan (63) reported an operation in a man with an apparently localized Hodgkin's disease of the spleen, but the generalized nature of the process has caused the operation to be little used in this disease.

Leukemia appears to be a pathological proliferation of the leukopoietic system of the body, either myeloid or lymphoid in nature. The acute form of the disease usually occurs in young children or adults, and the chronic leukemias are more often myeloid than lymphoid in character. The first case in which the spleen was excised in myelog-

enous leukemia is recorded by Bryant (13) in 1866, the patient dying immediately following the operation. The mortality of the operation in myelogenous leukemia before the year 1900 is reported as just under 90% (63), and in Johnston's 1908 series (48) only 2 out of 7 operated cases survived the operation. Griffin (38) reported that the total number of operated cases in the literature prior to 1918 was 51. In this series the immediate operative mortality proved to be 84%, and hence it is not surprising that the operation fell into disfavor as a therapeutic measure in myelogenous leukemia. However, in cases subjected to pre-operative radiation therapy, the experience has been decidedly different, with an operative mortality of only 3.8% (61), and hence splenectomy under these conditions might be favorably considered. Griffin (39) in 1927 concluded that splenectomy is warranted in patients where the disease has been of less than a year's duration and who show no evidence of an acute exacerbation. He states that in these cases a prolongation of life and general health may be promised with a fair degree of confidence.

A search through the literature, however, tends to reveal that fewer and fewer cases of leukemia are being subjected to splenectomy, and at the present time little or no reference to splenectomy as a therapeutic procedure

in myelogenous leukemia can be found. According to Vincent and Hanrahan (91) the operation in the lymphatic form of leukemia has been reported mainly from the European Clinics, and in this form of the disease the condition is also unchanged by splenectomy.

Prior to the modern treatment of pernicious anemia by the Murphy-Minot liver diet (since 1926), splenectomy was performed in this disease with the hope of obtaining some of the clinical improvement seen in the similar condition of hemolytic jaundice. Three observers independently suggested splenectomy in pernicious anemia in 1913 (63), Eppinger advocating the operation because he had observed a diminished hemolysis of the blood in other diseases following the operation and hence thought the operation might be of benefit in the control of increased hemolysis in pernicious anemia. DeCastello was guided by the observations of the effect of splenectomy in splenic anemia and hemolytic jaundice, and Klemperer noticed that splenectomy was followed by a polycythemia in many cases. Although the procedure quickly became quite popular among surgeons, it became evident after a few years that the procedure failed to show more than a temporary amelioration of the disease process. (Vincent and Hanrahan, 91). Bloomfield (10) found that none of 6 patients who survived splenectomy were benefited by the operation, and in the

series of Griffin and Szlapka (40) the operation seemed to prolong the life of only 20% of the cases.

It would seem, therefore, that the operation of splenectomy in pernicious anemia was of no value whatsoever, and the timely discovery of a specific form of therapy in 1926 doubtless prevented the needless removal of the spleen in further cases. Why the operation failed to be of benefit in this disease that so closely simulates other conditions benefited by the operation is another question for speculation.

Polycythemia vera is a disease in which the red blood cell count is elevated above 6 million cells per cubic millimeter (63), and the etiology is unknown. Certain cases of polycythemia follow fibrosis of the lung, emphysema and other lung conditions (probably a compensatory action in order to supply sufficient oxygen to the body tissues), and the condition has also followed such poisons as arsenic and phosphorus, which cause a hemoglobinuria. Polycythemia has occurred in the course of recognized diseases of the spleen (63), such as primary tuberculosis of the spleen, hydatid cyst, Banti's disease, and hemolytic jaundice. True polycythemia, or the Vaquez-Osler malady, runs a progressive and usually fatal course lasting a few years.

The spleen was removed in this disease by Blad in 1905

with fatal result (63). Mayo (61) removed the spleen in 3 cases up to 1928, and stated that the results in two cases were extraordinarily good. Moynihan (63), however, states that it is the spleen which helps keep this disease in check and that splenectomy is therefore contraindicated. Present day texts fail to mention splenectomy as a therapeutic procedure in this condition, and one is safe in stating that, at the present at least, splenectomy appears to be of no value in polycythemia vera.

Technique of Splenectomy

Splenectomy is today the most frequently employed operation on the spleen. Other operations include splenotomy, splenopexy and ligation of the splenic artery, but these procedures are useful only when the more radical operation of splenic removal is either unnecessary or too dangerous. (Mayo, 59).

Splenectomy, or excision of the spleen, is an operation of variable difficulty, depending for the most part on the presence of an adherent or non-adherent spleen. The chief danger of the operation is hemorrhage, and when heavy vascular adhesions are present, a certain amount of bleeding is unavoidable. (Balfour, 2). Since one cannot tell with absolute certainty before the abdomen is opened whether or not the spleen in adherent, the surgeon must be prepared to handle either a simple or difficult splenectomy. To surmount this difficulty, Bevan (7) advocates the use of a straight midline incision which may be enlarged in difficult cases by dividing the rectus muscle. Little risk of postoperative hernia is encountered because the nerve supply of the abdominal wall is not injured by a midline incision, and adequate exposure of the spleen can be gained in all cases.

Removal of the normal spleen is a comparatively easy procedure (7). The operation resolves itself into freeing the peritoneal attachments, rotating the spleen on its

pedicle forward and inward (carrying the stomach and pancreas with it) and bringing it out of the incision. The 5 or 6 veins and arteries of the pedicle are separately ligated, being careful not to injure the tail of the pancreas.

In pathological conditions of the spleen the procedure becomes more difficult. Balfour (2) believes that it will be found most efficient to deal with all accessible adhesions before any attempt is made to mobilize the spleen. Then while the spleen is retained in the abdomen as a barrier against intestinal protrusion, the vascular connections between the spleen and the stomach are ligated, care being taken not to injure the stomach. (Mayo, 59). The space from which the spleen has been removed may be packed with hot normal saline packs as a good means of hemostasis. (Bevan, 7). Wise (99) describes a method whereby a rubber shod intestinal clamp is used on the pedicle. This may include some of the greater curvature of the stomach and the pancreas without fear of damage to these structures. He also advocates burying the ligatured ends of the vasa brevia of the stomach with a pursestring of silk taken in the greater curvature of the stomach as a means of positive hemostasis. The abdomen should be closed without drainage, unless it is necessary to leave in a pack for 48 to 72 hours to control bleeding. (Bevan, 7)

Summary

With a few exceptions, the operation of splenic removal must still be regarded as resting mainly on an empirical basis. The past forty years has been marked by the widespread application of splenic removal to certain of the splenomegalies, with surprising clinical improvement in several instances. Since, however, the physiology of the spleen and the pathological physiology of most of the diseases in which the spleen is involved are at best but incompletely understood, confusion still exists as to the absolute indications for splenectomy.

Largely because of this incomplete knowledge of the splenic physiology, splenectomy has been attempted in a wide variety of conditions, most of them, however, being distinguished by the presence of splenomegaly. Out of this experimental clinical attitude has evolved most of our present knowledge of the indications for splenic removal, and fairly definite indications for the operation are known today to exist in a few of the splenomegalies. Besides the imperative indications for the operation such as wounds of the spleen, rupture, movable spleen, abscess, cysts, tumors, etc., splenectomy has been found to be an excellent procedure in certain of the blood dyscrasias. At the present writing, splenectomy seems to be definitely indicated in hemolytic jaundice, idiopathic thrombocytopenic purpura, and splenic anemia. Evidence

is accumulating that the operation may benefit, to a lesser extent perhaps, the diseases of sickle cell anemia and familial gravis neonatorum. As might be expected where an operation rests on such an empirical basis, splenectomy has been performed in several conditions without apparent clinical improvement. Among these are Hodgkin's disease, leukemia, pernicious anemia and polycythemia vera.

It may be that the future will reveal much more of the influence of the spleen in these conditions, and a rational basis for the operation of splenectomy will probably then appear.

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